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CLASSIFICATION AND LIMITATIONS OF  
STATISTICAL GRAPHICS.

BY E. A. GOLDENWEISER.

Graphic methods of presenting statistical facts have been in use from times immemorial and are doubtless destined to become increasingly popular. Mr. Willard C. Brinton's book on Graphic Methods of Presenting Facts (*The Engineering Magazine*, 1914) and the subsequent creation of a committee of representative men from various fields of endeavor for the study and standardization of graphics are indications of the increasing interest in the matter and are themselves in part responsible for this increased interest. The committee has made a preliminary report\* in which it lays down seventeen elementary rules to be followed in presenting facts graphically. Considering the wide divergence of interests on the part of the members of the committee, which includes engineers, economists, statisticians, psychologists, mathematicians, accountants, educators, and others, the report must be considered as a substantial achievement and a decided step in the direction of standardization. The great need of standardization was perhaps the principal fact impressed upon the visitor to the exhibit of graphics held under the auspices of the committee in connection with the sessions of the Second Pan-American Congress and of the various scientific societies that met in Washington, the last week of December, 1915.

It is the object of this paper to contribute to the work of standardization by attempting to classify the uses of graphic methods and to delimit briefly their fields of greatest usefulness. The discussion is confined to statistical graphics and does not touch upon devices like organization charts, routing charts, and the like, the subject matter of which is not statistical.

Statistical graphs may be classified in the first place according to method of presentation and secondly in relation to primary object. The classification on both of these bases might be presented as follows:

\* See QUARTERLY PUBLICATIONS of the American Statistical Association, December, 1915, p. 790.

## STATISTICAL GRAPHICS.

Method of presentation.	Object.
I. Publication in books or bulletins. . . . .	<ol style="list-style-type: none"> <li>1. Reference</li> <li>2. Illustration</li> <li>3. Analysis</li> <li>4. Research</li> </ol>
II. Use at lectures. . . . .	<ol style="list-style-type: none"> <li>1. Reference</li> <li>2. Illustration</li> <li>3. Analysis</li> </ol>
III. Use in exhibits. . . . .	<ol style="list-style-type: none"> <li>1. Reference</li> <li>2. Illustration</li> <li>3. Analysis</li> </ol>

The discussion will take up the graphs devoted to each of the four primary objects and will refer to the methods of presentation only incidentally. It may be noted at the start that graphs are often, if not generally, used for more than one of the objects mentioned, and quite properly so; nevertheless, a clear understanding of the primary object for which the graph is prepared will be helpful in deciding on its character and arrangement.

1. *Reference Graphs.* A graph, like a general table, may be prepared with no other object than to present a given set of facts. A curve showing the value of exports during a series of years is such a graph; a series of forty-eight bars showing the population of each state is another; and a map showing, by means of dots, the distribution of a crop is a third. The map, however, contains certain elements of correlation: the geographic location and concentration of the crop stands out; it appears whether the crop is in the South, the North, or the West; furthermore, a common knowledge of the location of the principal cities and rivers superimposes a mental set of correlations, even if the map is actually shown in bare outline. If the map shows isotherms, isobars, or topographic contours, it becomes an analytical graph. As a general proposition reference graphs are seldom of value unless they carry a time series, like the curve, or a geographic relationship, like the map. In other words, their value is dependent on their being more than pure repositories of facts. The bar

diagram mentioned would probably be valueless unless the states were arranged in descending order, thus introducing a relationship. It may be said, therefore, that reference graphs are to be used with caution; they are often a waste of time and space. If used at all, reference graphs must be absolutely simple and clear, for their only excuse is that they may be more easily comprehended by eye-minded readers than a statistical table which is generally more compact, more accurate, and more easily handled.

Graphic methods are most effectively applied not to raw material but to results. There would be little excuse for stating this were it not for the fact that numerous graphs are published that have no apparent object other than to reproduce unassorted facts. Such graphs may be of some use in a lecture by helping the lecturer to pin his words to a concrete exhibit, but in a printed publication or an exhibit a graph should never be shown unless it helps bring out some significant relationship more clearly than do the text and tables.

2. *Illustrative Graphs.* An illustrative graph differs from a reference graph in that the former is selective while the latter is inclusive. A bar diagram comparing the corn production of Illinois with that of the United States is illustrative; so is a series of bars showing the number of deaths from given causes. An illustrative graph is very useful in print, as well as in lectures or exhibits, because it helps to fix in the mind of the reader some important fact that may be the key-note of a discussion. Such a graph should be very simple since it is an appeal to visual memory, and if, in order to remember correctly, one needs to keep in mind many items and qualifications that are not impressed on the eye, the graph loses a considerable part of its usefulness. An illustrative graph may be comparatively complex and not self-explanatory if it is intended for use in connection with a lecture where the speaker has the opportunity of pointing out the significance of the chart. Such a graph serves a somewhat different purpose from that of graphs on a printed page: it has a psychological value in giving the audience something to look at and helps hold their attention. This advantage

is forfeited, however, when the lecturer has too many charts, or exhibits more than one at a time, or spends too much time in adjusting one after the other. In such cases the attention of the audience is diverted from rather than attracted to the discussion.

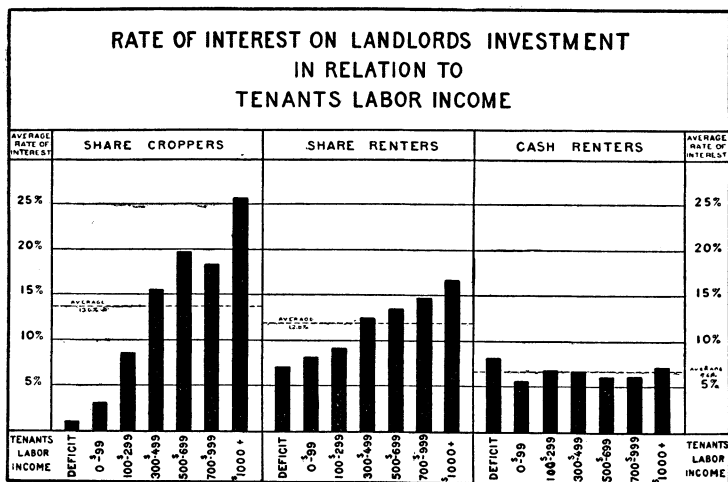
3. *Analytical Graphs.* An analytical graph is seldom used except in connection with printed text or a lecture; at an exhibit it would demand too much explanation. An analytical graph is one that is introduced into a discussion in order to show visually a relationship that the author wishes to emphasize. A graph consisting of two curves—one showing the value of the potato crop through a series of years and the other the production of the same crop—is analytical. The two curves are brought together in order to emphasize the circumstance that a large crop often results in so low a price that the total value of the large crop is smaller than that of a smaller crop harvested during another year. Such a graph is of distinct value because the correlation is made much plainer by the curves than it can be made by text and tables alone. A map showing mean summer temperature and the distribution of a crop is analytical in that it exhibits the temperature control of the crop. Another illustration of an analytical graph is shown in the accompanying diagram, taken from a bulletin of the Department of Agriculture.\*

The fact that the landlord's rate of interest varies greatly in one class of tenure in conjunction with the tenant's income, while in the second class the variation is much less, and in the last class it is insignificant, stands out more clearly from this graph than from any amount of discussion. One may perhaps be justified in the belief that it is in the field of analysis that lies the greatest usefulness of statistical graphics. A graph of this sort not only visualizes a conclusion previously reached but even helps to reach the conclusion and thereby approaches the last type of graph to which we now turn.

4. *Research Graphs.* A research graph is one that helps establish an unknown correlation as a result of plotting ascertainable data. This type of graph, used largely in the laboratory and in print, is more common in engineering and natural

\* U. S. Dep't of Agr. Bulletin No. 337, p. 13.

science than in statistics, but statisticians sometimes receive hints of possible relationships from experimental research graphs. These graphs are not, like the others, primarily a method of presenting, but of discovering a relationship. This highest form of graphics lies on the fringe of the subject of this paper and may be respectfully dismissed with these few words.



In conclusion, it may be stated that the great need in statistical graphics, as in statistics, is not for greater output but for higher quality. Standardization of method is highly desirable, but it is essential for statisticians to understand clearly that graphic methods for them are merely subsidiary and are valuable as a rule only in so far as they help to popularize the results of study. A transformation of a table into a graph, and especially of a good table into a bad graph, is not a statistical achievement. The statistician should not permit his interest in the graphic presentation of his material to divert him from his main work of careful statistical interpretation, the insufficiency of which is today the crying need in the study of social conditions.